# Article

## Cystotomy practices and complications among general small animal practitioners in Ontario, Canada

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**Abstract —** Cystotomy is a common surgical procedure in small animal veterinary medicine, yet common pre-, intra-, and post-operative practices have not been described. This survey evaluated cystotomy practices of 106 veterinarians in Ontario. The majority of respondents reported practices consistent with standard recommendations, but some deficiencies in antimicrobial and analgesic use, as well as intra- and post-operative practices, were identified. Some factors associated with the likelihood that practitioners reported recurrent urolithiasis or urinary tract infection are contrary to typical recommendations, such as the association of the use of absorbable, multifilament suture or a dorsal (versus ventral) incision and a lesser likelihood of reporting post-operative urinary tract infections. While care must be taken interpreting these statistical associations, the results suggest that objective assessment of common cystotomy recommendations (use of monofilament, absorbable suture) is required. Re-assessment of certain peri-operative practices, such as analgesic and antimicrobial administration, and post-operative testing, is required for a minority of practitioners.

**Résumé — Pratiques de cystotomie et complications parmi les praticiens pour petits animaux en Ontario, au Canada.** La cystotomie est une intervention chirurgicale courante en médecine vétérinaire pour petits animaux, pourtant les pratiques pré-opératoires, intra-opératoires et post-opératoires n'ont pas été décrites. Ce sondage a évalué les pratiques de cystotomie de 106 vétérinaires en Ontario. La majorité des répondants ont signalé des pratiques conformes aux recommandations standards, mais certaines lacunes à l'égard de l'utilisation des antimicrobiens et des analgésiques, ainsi que les pratiques intra-opératoires et post-opératoires, ont été identifiées. Certains facteurs associés à la probabilité que les praticiens signalent de l'urolithiase ou des infections des voies urinaires sont contraires aux recommandations typiques, comme l'association de l'utilisation de suture résorbable multifilament ou d'une incision dorsale (par opposition à ventrale) et d'une probabilité réduite de déclaration d'infections des voies urinaires après l'opération. Bien qu'il faille interpréter prudemment ces associations statistiques, les résultats suggèrent que l'évaluation objective des recommandations courantes pour la cystotomie (utilisation du monofilament, d'une suture résorbable) est requise. La réévaluation de certaines pratiques péri-opératoires, comme l'administration d'analgésique et d'antimicrobien et les tests post-opératoires, est requise pour une minorité de praticiens.

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### Introduction

Cystotomy is a common surgical procedure in small animal veterinary practice, typically performed to remove cystic calculi (1). Complications that can develop include uroabdomen, urinary tract infection (UTI), surgical site infection, incomplete removal of uroliths, recurrence of cystic calculi, and lower urinary tract obstruction. Surgical technique, including peri-operative and post-operative antimicrobials and analgesics, and suture selection and pattern, probably play an important role in the likelihood of these complications, yet objective data are lacking.

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Ventral bladder wall incisions are often recommended because dorsal incisions are thought to predispose to complications as a result of decreased visualization and the anatomic proximity of the ureters. Absorbable, monofilament suture is often recommended because suture can act as a foreign body nidus and predispose to formation of cystic calculi (2,3). Two-layer closure is widely recommended for bladder walls of normal thickness to help produce a water-tight seal. Despite the presence of standard recommendations, there has been little objective study of current practices or the impact of these practices on complication rates. While there are recommendations for location of cystotomy incision, suture types and patterns for cystotomy closure (1,2,4–7), there is little scientific evidence supporting these recommendations. Moreover, relatively little is known about common peri-operative and post-operative use of antimicrobials or analgesics (8,9). Inappropriate antimicrobial use may increase risk of infection and cause untoward side effects, such as diarrhea and selection for antimicrobial resistance (8). Lack of an appropriate analgesic regimen may impair healing (10), and contribute to post-operative complications (10–12) and animal welfare concerns.

In order to design proper studies to assess the impact of various practices on complication rates, baseline information about current practices is needed. Accordingly, the objectives of this study were to characterize cystotomy practices performed by general practitioners in Ontario, Canada and to provide a preliminary assessment of self-reported complications and factors associated with complications.

## Materials and methods

A cross-sectional survey of veterinarians licensed by the College of Veterinarians of Ontario (CVO) was performed between November 2007 and January 2008. A random selection of veterinarians from the CVO database with a designation of a small animal or mixed animal practitioner was obtained through use of a random number generator. A total of 300 veterinarians were invited by mail to complete a pre-tested survey regarding cystotomy practices. The survey queried: i) the practitioner's years in practice, practice location, and area classification [rural, small town (population $<$ 10 000); urban (10 000 to 490 000 people); large urban ($>$ 500 000 people)], the proportion of the practice that was small animal, and if they worked full or part time; ii) whether or not the practitioner performed certain common surgical procedures, and the annual number of feline and canine cystotomies performed by the practitioner; iii) pre-cystotomy practices performed by the practitioner such as abdominal radiographs, urinalysis, complete blood cell count, biochemistry, abdominal radiographs, abdominal ultrasound, urine culture, ECG, pre-operative antimicrobials, and analgesics; iv) intra-operative practices, including administration of intravenous fluids, peri-operative antimicrobials, location of cystotomy incision (ventral or dorsal), and suture selection (suture type, size, and pattern); v) post-operative practices including antimicrobials, analgesics, re-check urinalysis and urine culture, abdominal radiographs, abdominal ultrasound, and complications (recurrent urolithiasis, UTI, diarrhea and miscellaneous others); vi) where the practitioners learned the cystotomy technique (DVM education, literature, or colleagues), and vii) complications encountered in cystotomy patients during the preceding year.

Descriptive statistics were calculated to summarize the data. Associations between variables and the 2 main complications, recurrence of uroliths and post-operative UTI, were evaluated. The 2 outcomes were defined as the recurrence of uroliths or the diagnosis of UTI within 1 year of cystotomy. Unconditional associations between the 2 outcomes and variables for which data were collected were assessed using univariable logistic regression. Continuous variables were assessed for a linear association with each outcome. A Wald $P$-value of $\leq 0.05$ was considered significant.

Multivariable logistic regression was performed to evaluate conditional associations between the 2 outcomes and all variables with a likelihood ratio $P$-value $\leq 0.20$ in the unconditional analyses. Models were built using a manual backwards-stepwise approach. Two-way interactions were considered between all variables significant to the final model and potential confounding variables. The gender of the respondent, school of attendance, proportion of small animal practice (100%, 80%, or 50%), type of work (full-time, part-time, or locum), and practice area classification (large urban, urban, or small town/rural) were assessed for confounding effects on the final model variables and were included in the model if they altered the log odds of any model coefficient by $>$ 25%. Final models included variables with a likelihood ratio $P$-value $\leq 0.05$. The fit of the final multivariable models was assessed using the Hosmer-Lemeshow chi-squared ($\chi^2$) test and residual analyses. Final models were run as multilevel models with a random intercept for location and compared for model fit against the single-level models using the Bayesian Information Criteria; a lower number indicated a model with better fit and that model was selected (13).

## Results

A total of 119 (40%) responses were received. Thirteen responses were excluded from analysis as the practitioner did not perform cystotomies ($n$ = 11), the survey results were predominantly incomplete (1) or the respondent was a board certified surgeon (1). One-hundred and six completed surveys were used for analysis. Seventy-four of the respondents were female, and 32 were male. The mean year of graduation from veterinary school was 1991 (range: 1967–2006) with a mean of 16.5 y experience (range: 2 to 41 y). Ninety-three (88%) of the respondents were graduates of the Ontario Veterinary College, 8 (7.5%) from the Atlantic Veterinary College, 1 (0.9%) from Faculté de médecine vétérinaire, St-Hyacinthe, and 4 (4%) from other countries (United States, India, Europe, South Africa). Eighty-nine of the respondents worked exclusively (100%) with small animals, 13 predominantly (at least 80%) with small animals, and 4 worked with small animals at most 50% of the time. Eighty-four practitioners worked full time, 19 part time, and 3 as locums. Seventy-seven (73%) respondents worked in an urban practice, 18 (17%) in a small town, and 11 (10%) in rural areas.

Responding practitioners performed a mean of 5.0 canine (range: 1 to 30) and 2.5 feline (range: 0 to 12) cystotomies

**Table 1.** Pre-cystotomy practices (percentages) reported in a survey of 106 veterinarians

| Procedure | Always | Often | Sometimes | Never |
|---|---|---|---|---|
| Abdominal radiographs | 97 | 3 | 0 | 0 |
| Abdominal ultrasound | 5 | 14 | 52 | 29 |
| Biochemical profile | 79 | 18 | 3 | 0 |
| Complete blood cell count | 72 | 21 | 7 | 0 |
| Urinalysis: dipstick | 92 | 3 | 4 | 1 |
| Urinalysis: in-house cytology | 82 | 6 | 9 | 3 |
| Urinalysis: external lab | 14 | 10 | 51 | 25 |
| Urine culture: in-house | 0 | 3 | 5 | 92 |
| Urine culture: external lab | 34 | 30 | 29 | 7 |
| Electrocardiogram | 6 | 5 | 37 | 52 |

annually. The majority of practitioners performed cystotomies to remove uroliths, with 70% reporting this as the exclusive reason and the remaining 30% performing 80% to 99% of cystotomies to remove uroliths. Thirty-six percent reported learning their cystotomy technique from their DVM education, 37% from literature, 18% from colleagues in their clinic, and 10% from other (undefined) sources.

## Pre-operative practices

Pre-operative assessment tests are summarized in Table 1. Eighty-six (81%) practitioners reported administering peri-operative antimicrobials to dogs undergoing cystotomy, while 82 (77%) used antimicrobials in cats. Thirty-two (30%) practitioners administered the first dose of antimicrobials more than 1 h prior to surgery, 32 (30%) during the time from induction to skin incision, 2 (1.8%) intra-abdominally, and 9 (8.5%) during recovery. Ampicillin, amoxicillin/clavulanic acid, and cefazolin were the most commonly administered peri-operative antimicrobials.

Ninety practitioners (90%) always provided pre-operative analgesia to dogs, and 86 (93%) to cats. In contrast, 4 (3.8%) and 3 (2.8%) practitioners reported never providing pre-operative analgesia to dogs and cats, respectively. Non-steroidal anti-inflammatory drugs (NSAIDs) were the most common pre-operative analgesic provided, used by 38% of practitioners for canine cystotomies and 34% of feline cystotomies. Opioids such as hydromorphone, were also used commonly, accounting for 29% and 27% of canine and feline pre-operative cystotomy analgesia, respectively. A minority of practitioners used butorphanol, or a combination of an NSAID and opioid.

## Intra-operative practices

Intra-operative practices are summarized in Table 2. Thirty-nine practitioners (37%) made a dorsal incision in the bladder while 63 (59%) made ventral incisions, and 4 (4%) used either approach. Veterinarians who used a dorsal approach had a mean of 20.4 y in practice (range: 2 to 41 y), which was significantly different from those using a ventral approach, who had a mean of 13.7 y (range: 2 to 40 y) ($P$ = 0.002). Most practitioners (86%) closed the cystotomy incision in 2 layers, 11 (10%) closed in 1 layer, and 4 (4%) closed in 3 layers. Poliglecaprone 25 (Monocryl) was the most commonly used suture for both feline and canine cystotomies (40% canine and feline), followed by polydioxanone (PDS) (25% canine and 22% feline),

**Table 2.** Intraoperative practices (percentages) during cystotomies reported by 106 veterinarians

| Practice | Always | Often | Sometimes | Never |
|---|---|---|---|---|
| Intravenous fluid therapy | 86 | 9 | 5 | 0 |
| Pass urinary catheter and flush retrograde | 73 | 19 | 7 | 1 |
| Bladder mucosal biopsy | 19 | 9 | 34 | 38 |

**Table 3.** Post-operative practices (percentages) reported by 106 veterinarians

| Procedure | Always | Often | Sometimes | Never |
|---|---|---|---|---|
| Abdominal radiographs | 52 | 15 | 22 | 11 |
| Abdominal ultrasound | 1 | 0 | 10 | 89 |
| Biochemical profile | 1 | 2 | 43 | 52 |
| Urinalysis | 78 | 0 | 0 | 22 |
| Urine culture | 14 | 17 | 29 | 40 |

**Table 4.** Complications in canine and feline cystotomy patients over the preceding year as reported by 106 veterinarians

| Complication | Percent |
|---|---|
| Recurrent uroliths | 42 |
| Urinary tract infection | 29 |
| Uroabdomen | 5 |
| Ureteral damage | 1 |
| Urethral damage | 3 |
| Urethral obstruction by urolith | 1 |
| Persistent hematuria | 1 |
| Renal failure | 1 |
| Incision infection | 3 |
| Diarrhea | 8 |
| IV catheter site complication | 1 |
| Polyp | 1 |

and Polyglactin 910 (Vicryl) (17% canine and 18% feline). Using exclusively size 3-0 suture was the most common ($n$ = 49 and 50) in both dogs and cats, respectively, followed by 2-0 ($n$ = 14 and 6). Five practitioners reported using either 3-0 or 4-0, and 2 practitioners reported using size 0. The majority of practitioners reported not taking full thickness bites (61%), whereas 26% reported sometimes taking full bites and 13% always took full thickness bites. Fifty practitioners had contradictory answers regarding their suture patterns for cystotomy closure (for example, they stated using a non-inverting technique, but listed an inverting suture pattern).

## Post-operative practices

Post-operative practices are summarized in Table 3. All practitioners reported submitting uroliths removed for analysis. Seventy-eight percent obtained urinalysis a mean of 19 d after surgery (range: 7 to 60 d). One-quarter of respondents cultured the patient's urine, doing so an average of 24 d after surgery (range: 1 to 90 d).

Forty (48%) practitioners continued antimicrobials post-operatively regardless of whether there was evidence of infection or inflammation, whether inflammation was present surgically, or whether a UTI was diagnosed pre-operatively. Twenty-three (27%) only continued antimicrobials if a UTI was diagnosed pre-operatively, and 14 (17%) continued antimicrobials if the bladder appeared inflamed at surgery or a UTI was diagnosed

**Table 5.** Results of the univariable analysis of risk factors for association with veterinarians reporting the recurrence of bladder uroliths in patients following cystotomy. All listed variables were offered to the multivariable model (likelihood ratio $P \leq 0.20$)

| Risk factor | Category | Percent | OR | 95% CI |
|---|---|---|---|---|
| Year of graduation | Grad year (median centered) | NA | 0.98 | 0.93–1.03 |
| | (Grad year)$^2$ (median centered) | NA | 0.995[a] | 0.991–0.999 |
| Annual number of cystotomies | Canine number | NA | 1.08 | 0.98–1.18 |
| | Feline number (median centered) | NA | 1.52[a] | 1.04–2.21 |
| | (Feline number)$^2$ (median centered) | NA | 0.94[a] | 0.881–0.996 |
| Pre-operative ultrasound | Never | 29 | 1.00 | Reference |
| | Sometimes | 52 | 0.73 | 0.29–1.82 |
| | Often/Always | 18 | 2.24 | 0.69–7.29 |
| Bladder mucosal biopsy | Never | 38 | 1.00 | Reference |
| | Sometimes | 34 | 3.30[a] | 1.27–8.57 |
| | Often | 9 | 3.95 | 0.93–16.74 |
| | Always | 19 | 1.76 | 0.57–5.45 |
| Cystotomy technique reference | DVM degree | 36 | 1.00 | Reference |
| | Vets in clinic | 18 | 3.18 | 0.99–10.22 |
| | Literature | 37 | 0.44 | 0.16–1.19 |
| | Other | 9 | 2.93 | 0.63–13.6 |
| Full-thickness sutures | Never | 61 | 1.00 | Reference |
| | Sometimes | 26 | 0.78 | 0.31–1.94 |
| | Always | 13 | 0.31 | 0.08–1.21 |
| Postoperative urine culture | No | 40 | 1.00 | Reference |
| | Yes (sometimes, often, always) | 60 | 2.08 | 0.91–4.77 |
| Postoperative urinalysis | No | 22 | 1.00 | Reference |
| | Yes (sometimes, often, always) | 78 | 2.57 | 0.92–7.17 |
| Canine perioperative antibiotics | No | 19 | 1.00 | Reference |
| | Yes | 81 | 0.37 | 0.13–1.05 |
| Feline perioperative antibiotics | No | 23 | 1.00 | Reference |
| | Yes | 77 | 0.44 | 0.16–1.19 |

[a] $P < 0.05$.
NA — not applicable.
OR — odds ratio.
CI — confidence interval.

pre-operatively. Amoxicillin/clavulanic acid was the most commonly prescribed post-operative antimicrobial for both cats and dogs, followed by enrofloxacin and then amoxicillin. The mean duration of treatment for both cats and dogs was 13 d (range: 2 to 25 d).

Eight-one percent of practitioners reported always providing post-operative analgesia to canine and feline cystotomy patients, and 16% reported providing analgesia sometimes. Non-steroidal anti-inflammatory drugs (NSAIDs) were the most common form of post-operative analgesia, accounting for 58% and 55% of canine and feline cystotomy patients, respectively. The mean reported minimum and maximum durations of administration of analgesic were 3.5 to 5 d (range: 0 to 14 d) in dogs and 3 to 4 d (range: 0.5 to 14 d) for cats.

## Complications

Post-operative complications identified by veterinarians in the preceding year are summarized in Table 4. The most common complications reported were recurrent uroliths (42%) and urinary tract infections (29%).

## Statistical analyses

Results of the univariable analyses of risk factors for recurrent uroliths and UTIs following cystotomy surgery are presented in Tables 5 and 6, respectively.

The final models for both recurrent uroliths and UTIs following cystotomy surgery were run as multilevel logistic models with a random intercept for location. However, the majority of respondents were the only observation from their specific location. The single level models for both had lower Bayesian Information Criteria than the random intercepts models (data not shown). As a result, the single level models were reported as the final multivariable models. There were no significant interactions for either model. Both models were deemed to fit the data (Hosmer-Lemeshow $\chi^2$ $P > 0.05$) and the residual analyses were appropriate for binary data; the removal of any values with extreme values, leverage, or influence did not change the final models, so all were included.

Conditional risk factors significantly associated with veterinarians reporting recurrent uroliths from the multivariable model are presented in Table 7. Veterinarians who referred patients to a colleague within their clinic (OR 0.07, $P = 0.012$, 95% CI: 0.01–0.57) or to another veterinary clinic (OR 0.03, $P = 0.002$, 95% CI: 0.003–0.28) for extracapsular cruciate repair were significantly less likely to have patients with recurrent uroliths after cystotomy surgery. Veterinarians who consulted the literature for their surgical technique were less likely to have patients with recurrent stones (OR 0.12, $P = 0.012$, 95% CI: 0.02–0.65) compared to those who relied on their DVM training for surgical reference. The practice area classification,

**Table 6.** Results of the univariable analysis of risk factors for association with veterinarians reporting post-cystotomy urinary tract infections in patients. All listed variables were offered to the multivariable model (likelihood ratio $P \leq 0.20$)

| Risk factor | Category | Percent | OR | 95% CI |
|---|---|---|---|---|
| Practice area classification | Large urban (> 500 000) | 20 | 1.00 | Reference |
| | Urban | 53 | 0.73 | 0.25–2.16 |
| | Small town (< 10 000) | 17 | 0.40 | 0.09–1.86 |
| | Rural | 10 | 2.40 | 0.54–10.69 |
| Annual number cystotomies | Feline number (median centered) | NA | 1.63[b] | 1.02–2.62 |
| | (Feline number)$^2$ (median centered) | NA | 0.88[b] | 0.77–1.01 |
| Surgery technique reference | DVM degree | 36 | 1.00 | Reference |
| | Vets in Clinic | 18 | 0.35 | 0.10–1.26 |
| | Literature | 37 | 0.39 | 0.15–1.06 |
| | Other | 9 | 0.38 | 0.07–2.05 |
| Bladder incision | Ventral | 59 | 1.00 | Reference |
| | Dorsal | 37 | 0.30[b] | 0.11–0.81 |
| | Either | 4 | 0.54 | 0.05–5.51 |
| Canine bladder suture type | Absorbable, monofilament | 78 | 1.00 | Reference |
| | Absorbable, multifilament[a] | 22 | 0.18[b] | 0.04–0.82 |
| Feline bladder suture type | Absorbable, monofilament | 75 | 1.00 | Reference |
| | Absorbable, multifilament[a] | 25 | 0.36 | 0.10–1.38 |
| Pre-op K9 analgesics | Always | 91 | 1.00 | Reference |
| | Never | 4 | 7.50 | 0.75–75.44 |
| | Sometimes | 5 | 0.63 | 0.07–5.86 |

[a] Respondent reported sometimes or always using multifilament suture.
[b] Significant at $P < 0.05$. OR — odds ratio; CI — confidence interval.

proportion of small animal practice, and type of work were included in the final model as they were confounding the effects of the variables significantly associated with the recurrence of uroliths. Veterinarians administering any kind of perioperative antimicrobials to their canine patients were less likely to have patients experience recurrent uroliths (OR 0.09, $P = 0.003$, 95% CI: 0.02–0.44). Veterinarians submitting post-operative urine samples from some or all of their patients for bacterial culture were more likely to report recurrent urolithiasis (OR 10.23, $P < 0.002$, 95% CI: 2.29–45.78). Veterinarians had an increased risk of reporting recurrent uroliths as their graduation year increased until 1990–1995, after which it decreased (Figure 1).

The type of suture used, the location of the bladder incision, and a quadratic of the annual number of feline cystotomies were significantly associated with post-operative UTI (Table 8). The practice area classification was confounding the coefficients of these variables and was included in the final model. The risk of recurrent UTIs increased for veterinarians as they performed more feline cystotomies to approximately 3 to 5 per year; after this, the risk decreased (Figure 2). Veterinarians who reported using any type of absorbable, multifilament (versus monofilament) suture (OR 0.17, $P = 0.037$, 95% CI: 0.03–0.90) or who always used a dorsal (versus ventral) incision (OR 0.19, $P = 0.009$, 95% CI: 0.05–0.66) had a lower risk of reporting patients with recurrent UTI.

## Discussion

Despite the fact that cystotomy is a common procedure in veterinary medicine, there is little scientific evidence supporting current recommendations for surgical technique, suture selection, and pre-, peri-, and post-operative management. Recommendations may be based on general surgical principles, personal perceptions, and information extrapolated from other species, but there are no data supporting commonly made recommendations for dogs and cats.

Interestingly, some results from this study seem to contradict common recommendations for suture selection. Most current surgery texts and literature recommend absorbable, monofilament suture material for bladder surgery (2,4–6), as nonabsorbable suture may promote calculogenesis and multifilament suture is thought to harbor bacteria and debris that may form a urolith nidus (1,2,4,7). Most of these recommendations are unreferenced or based upon older *in vitro* studies and studies in species other than cats and dogs. However, there was no apparent effect of suture type on urolith recurrence herein, and a somewhat counterintuitive association between use of monofilament suture and increased risk of post-operative UTI. The reason for this is unclear but it certainly challenges the current dogma regarding suture selection. Vicryl was the most common absorbable multifilament suture used by responding practitioners. While all 3 of the most commonly reportedly used suture types — Monocryl, PDS, and Vicryl — are degraded by hydrolysis (4), complete absorption is fastest for Vicryl compared to Monocryl and PDS, both monofilament suture materials. It is possible that shorter absorption time of the multifilament Vicryl could be associated with the reported lower incidence of UTIs, since suture within the bladder lumen could harbor bacteria.

Respondents who used a dorsal bladder incision were less likely to report post-operative UTIs. The reason for this is unclear. Dorsal incision might reduce the risk of contamination from skin and subcutaneous tissues as the bladder is elevated with retroflexion. Additionally, it is possible that, due to gravity, the dorsal incision has less contact with residual bacteria in the urine that otherwise may pool and contribute to sediment

**Table 7.** Results of the multivariable analysis of risk factors for veterinarians reporting the recurrence of bladder uroliths in patients following cystotomy surgery

| Risk factor | Category | OR | 95% CI |
|---|---|---|---|
| Year of graduation | Grad year (median centered) | 0.98 | 0.91–1.08 |
| | (Grad year)$^2$ (median centered) | 0.988[a] | 0.905–0.996 |
| Extracapsular cruciate repair | Perform | 1.00 | Reference |
| | Refer in clinic | 0.07[b] | 0.009–0.57 |
| | Refer outside clinic | 0.03[a] | 0.003–0.28 |
| Postoperative urine culture | No | 1.00 | Reference |
| | Yes (sometimes, often, always) | 10.23[a] | 2.29–45.78 |
| Canine perioperative antibiotics | No | 1.00 | Reference |
| | Yes | 0.09[a] | 0.02–0.44 |
| Cystotomy technique reference | DVM degree | 1.00 | Reference |
| | Vets in clinic | 2.85 | 0.53–15.39 |
| | Literature | 0.12[b] | 0.02–0.65 |
| | Other | 2.12 | 0.21–22.66 |
| Proportion small animal practice[b] (%) | 100 | 1.00 | Reference |
| | 80 | 30.70 | 0.05–1.8 × $10^5$ |
| | 50 | 23.86[b] | 1.38–411.71 |
| Practice area classification[c] | Urban | 1.00 | Reference |
| | Large urban (> 500 000) | 2.61 | 0.50–13.69 |
| | Small town/rural (< 10 000) | 1.22 | 0.16–9.43 |
| Type of work[c] | Full Time | 1.00 | Reference |
| | Part Time | 12.20 | 0.001–> 1 × $10^5$ |
| | Locum | 0.17 | 0.03–1.10 |

[a] Significant at $P < 0.01$.
[b] Significant at $P < 0.05$.
[c] Variable was confounding the results of significant variables in the final model. OR — odds ratio; CI — confidence interval.

ventrally. However, unqueried factors that lead veterinarians to perform dorsal versus ventral incisions could be the reason for the difference. This finding indicates that further study should be undertaken to determine the impact of incision location on infection, since one may be present.

The effect of graduation year on recurrent urolithiasis was interesting and unexpected. One could have hypothesized *a priori* that recent graduates could be expected to have higher rates because of less surgical experience or lower rates because of the potential for use of more recent practices and adherence to practices taught during their veterinary training. Instead, veterinarians graduating in 1990–1995 had the highest rates. An explanation for this is not readily apparent, but the fact that an age-related difference was identified suggests that surgeon-related factors should be investigated prospectively to determine whether there are any risk factors that can be addressed. It was interesting that there was a similar pattern of increased risk of post-operative UTI in cats in relation to number of cystotomies performed, with risk increasing initially in practitioners who performed more procedures, then decreasing. The increased risk as the number of procedures increases is logical because a greater number of surgeries performed presumably increases the likelihood that a complication would occur in at least one. However, the subsequent decline in risk is interesting. Reasons for this are not apparent but it is possible that greater experience with the procedure in veterinarians who perform a larger number per year is associated with decreased risk of complications.

Whether respondents performed selected surgical procedures themselves was used as a crude proxy for surgical expertise and comfort. While unvalidated, it was based on the hypothesis that veterinarians who performed extracapsular cruciate repair had greater interest and experience with surgery. Accordingly, it was interesting that veterinarians who did not perform extracapsular cruciate repair reported a lower incidence of post-operative urolithiasis, despite the fact that there was only a slight and non-significant difference in the number of canine cystotomies performed and no difference in feline cystotomy numbers. When peri-operative antimicrobials are indicated, a general principle is that the first dose should be administered shortly before surgery (for example, 30 to 60 min before the first incision) to ensure that optimal tissue antimicrobial levels are present (4,8,9). In the current study, 32 (30%) practitioners

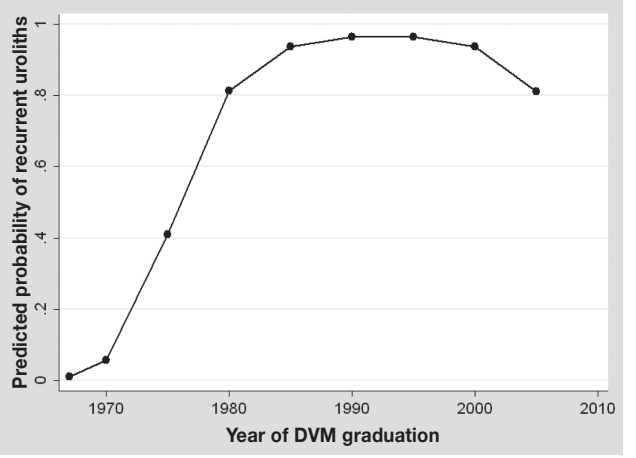


**Figure 1.** The predicted probability of a veterinarian having a patient with recurrent uroliths following cystotomy by their year of graduation from the multivariable logistic regression model. Probabilities were predicted while holding other model variables constant.

**Table 8.** Results of the multivariable analysis of risk factors for veterinarians reporting the recurrence of urinary tract infections in patients following cystotomy surgery

| Risk factor | Category | OR | 95% CI |
|---|---|---|---|
| Canine bladder suture type | Absorbable, monofilament | 1.00 | Reference |
| | Absorbable, multifilament | 0.17[b] | 0.03–0.90 |
| Annual number cystotomies | Feline number (median centered) | 1.84[b] | 1.05–3.23 |
| | (Feline number)$^2$ (median centered) | 0.86[b] | 0.74–0.99 |
| Bladder incision | Ventral | 1.00 | Reference |
| | Dorsal | 0.19[a] | 0.05–0.66 |
| | Either | 0.71 | 0.04–11.76 |
| Practice area classification[c] | Urban | 1.00 | Reference |
| | Large urban (> 500 000) | 1.51 | 0.38–6.07 |
| | Small town/rural (< 10 000) | 0.96 | 0.29–3.20 |

[a] Significant at $P < 0.01$.
[b] Significant at $P < 0.05$.
[c] Variable was confounding the results of significant variables in the final model.

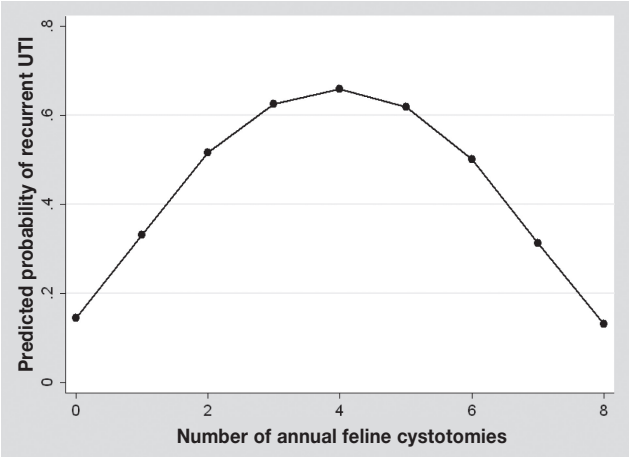


**Figure 2.** The predicted probability of a veterinarian having a patient with recurrent urinary tract infection (UTI) following cystotomy by the annual number of feline cystotomies they perform from the multivariable logistic regression model. Probabilities were predicted while holding other variables in the model constant.

administered antibiotics more than 1 h prior to surgery, creating a situation where drug levels are likely to drop below therapeutic levels during surgery, or even before surgery begins. Nine practitioners only administered antimicrobials after the surgery was completed, a practice that has been shown to have no ability to reduce infection rates, and which may, in fact, increase the risk compared to no antimicrobials whatsoever (14). Reasons for this approach were not queried. One possible explanation could be a desire to withhold antimicrobials if bladder wall or cystolith samples are to be collected intra-operatively for culture. This would still be a questionable approach because of the relative inefficacy of starting antimicrobials after the main time of potential contamination. Further, post-operative continuation of antimicrobial administration was common, even when there was no evidence of infection or inflammation in the bladder, something that is of questionable need. These results indicate that ongoing education regarding appropriate peri-operative antimicrobial use is required. Inadequate treatment could lead to an increased risk of surgical site infection or post-operative UTI, as well as urolith recurrence from infection-associated struvite uroliths. Further, inappropriate antimicrobial use could be a contributing factor to development of antimicrobial resistance, something that should itself be considered an important complication.

Peri-operative analgesia was commonly, but not universally, reported. While cystotomy is a relatively routine surgical procedure, it is an invasive procedure that is expected to be associated with post-operative pain. Failure of some veterinarians to report the use of any post-operative analgesia is quite concerning from an animal welfare standpoint.

It was also concerning that not all veterinarians passed a urinary catheter and flushed retrograde intra-operatively and took post-operative radiographs to help ensure that all uroliths were removed. Failure to identify and remove all uroliths is a problem that can lead to rapid post-operative recurrence of urolithiasis, along with other potential problems such as urinary tract obstruction. Failure to take these reasonable measures to ensure removal of all uroliths could be considered failure to follow an adequate standard of care.

Despite the associations that were identified here, care must be taken when interpreting results from a survey such as this, as clear evidence of causation cannot be identified. Therefore, this study should not be taken as an indication that use of multifilament suture will reduce the risk of infections. Rather, it is an indication that current recommendations may not be substantiated and that proper prospective study is warranted. Further, this study did not investigate effects and outcomes on individual cases. Rather, it assessed veterinarians' self-reported complications in all cases over a year and therefore was assessing general practices and overall outcomes. Additionally, rate-based data were not collected, so veterinarians performing fewer cystotomies would be less likely to encounter and report complications. Therefore, factors associated with reported complications could instead be factors associated with someone who performs more cystotomies. These limitations must be recognized but the data still provide useful information to indicate areas that require further study and to characterize current practices. While a response rate of 40% is not unusual for a study with passive recruitment, it introduces the potential for enrolment bias, since the respondents might be different than the overall population. Accordingly, the authors do not suggest using these survey-based results to make definitive pre-, intra-, and post-operative surgical management recommendations, but rather as a platform for further areas of inquiry.

This study provides important results regarding cystotomy practices and complications that require additional research. The result that absorbable multifilament suture and dorsal cystotomy incisions may produce fewer recurrent UTIs (but not recurrent cystoliths) than absorbable monofilament suture and ventral incisions, respectively, was unanticipated. Similarly, a possible prophylactic effect of perioperative antimicrobial administration on recurrent cystolithiasis is novel and warrants further study. The results of this study highlight the need for basing cystotomy recommendations not on isolated case reports or species other than companion animals but rather on controlled scientific studies in our patient population. CVJ

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# Book Review
## Compte rendu de livre

### Practical Small Animal MRI

Gavin PR, Bagley RS. Wiley-Blackwell, Ames, Iowa, USA. 2009. ISBN 9780-8138-0607-5. US$174.99. 362 pp.

Magnetic resonance imaging (MRI) is an area of veterinary diagnostics that is fast becoming the norm as we tend towards less invasive procedures that still provide a high precision of diagnosis. Although most MRI tests are carried out in referral centres, veterinarians still would like to understand more about the process and the images themselves.

An MRI is most useful for soft tissue imaging and as the authors explain, "the MRI portrayal of pathology results in a virtual autopsy". Multiplanar imaging will help identify tumor margins, characterize lesions, and improve specificity and diagnostic accuracy.

A text on the subject of the MRI is never picked up lightly… The subject is likely to make the average veterinarian uncomfortable. To me it truly is a "black box." However, this book is reasonably user friendly and seeks to teach and not overwhelm. The authors claim it to be a useful clinical text and not an exhaustive reference.

There is limited information on physics, sequence selection, and artefacts. Each chapter provides a small discussion on typical abnormalities found in that body region. "Normal" information is at a minimum, with emphasis on common misunderstandings and an attempt to share their 21 years of experience in the field. Images have been chosen to highlight common abnormalities. This is really more an atlas than a text, and the images chosen are a real asset to the book.

The text is well-written and organized. There are very few veterinary MRI books available to us, so this text is a welcome addition. Although likely to be used mainly by veterinarians in referral centres as a reference text, I could also see it as a handy aid to those wanting to broaden their knowledge or deepen their understanding of a pathological condition.

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